HANDBOOK

FOR

NOLAN RANGE FINDER.

MARK I.

FOR USE OF GARRISON ARTILLERY.

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Over the main telescope is placed an arm C working on a pivot near the eyeglass end by means of the screw *c*; over this pivot, and at right angles to the arm, is the cross telescope; at the other extremity is a vernier, which reads a graduated arc fixed near the object glass of the main telescope.

The cross telescope BB has its axis marked by cross wires, and is protected from injury by a cylindrical case fixed to the main telescope; on one end of this cylinder is a white face D (in plan), with two marks showing its vertical axis.

Vertical motion can be given to the main telescope by a screw *d* placed in the head of the tripod.

Vertical motion of the cross telescope is obtained by a screw *f*, which is placed just in rear of the focussing screw of the main telescope.

When (Fig. 1.) the instruments are at A and B, the lines of sight of the main telescopes, laid on the object C, are in the direction AC, BC. The cross telescopes are laid each on the face of the opposite cylinder, in the direction AB, and base angles can therefore be read by the arc and vernier.

Either instrument can of course read angles in one direction only.

The graduated arc and vernier have a notation differing from that in ordinary use. (Fig. 4.)

There are a number of large divisions, each marked O. When the arrow of the vernier points to any one of them the reading is 0. Between them are divisions marked 1, 2, 3, 4, $\overset{50}{|}$ 6, 7, 8, 9. These refer to tens, not units, the 50 in the centre being intended to show the fact. When the arrow points to any one of these the reading is the number multiplied by 10, *e.g.*, to 7, the reading is 70. If it is between any two marks, the intermediate units are read by the vernier, which has the numbers from 1 to 9 marked for the units, others between them for the halves. For instance, the arrow is between 6 and 7 of the arc, the reading is 60 and some units. Now, running the eye along the vernier, the mark which corresponds with any mark of the lower arc is the number required. Suppose the 5 of the vernier corresponds with any mark below, the reading is 65; if the smaller mark of the vernier towards 66 corresponds with any mark, it is $65\frac{1}{2}$, and so on. $99\frac{1}{2}$ is the highest number that can be read on this scale.

The cross telescope is approximately at right angles to the main telescope when the 5 of the vernier points to the zero of the arc immediately over the axis of the main telescope.

In laying, the intersection of the cross wires of the main telescope is laid on any well defined part of an object, for choice the right upper edge, to ensure, as far as possible, similarity. When there are two operators it is absolutely necessary to lay, not only on the same object, but on the same spot of the object. The vertical wires of the cross telescopes must correspond with the marks on the opposite faces of the cylinders.

It is not absolutely necessary that the horizontal wires should be exactly in the centre of an object or of a face, but they should

be as near it as possible. If the instruments are not on the same level, the cross telescopes can be moved till they are in a convenient position by a screw fixed near that used for focussing, but when this is done after the main telescopes have been laid, the latter must be looked through again to see that they are still correctly aligned.

The calculating disc has seven scales, marked A, B, C, D, on one side; E, F, and G, on the other.

A and B are two similar scales, divided into 100 parts. (Fig. 6.) The numbers run in the same direction. When, therefore, they are used together they add. As no hundreds are marked, none can be read, even should the sum of two angles be more than 100. To use them, proceed in the following manner. For instance, 14 + 23 is required. Place the zero mark of A to 14 on B, run the eye along A till 23 is found, over it, on B, will be found 37. Suppose the numbers are 94 + 23, proceeding as before over 23 on A will be found 17 on B. The hundred will have disappeared.

F and G are two similar scales. (Fig. 5.) The numbers run round the scales in opposite directions indicated by arrows. When contrasted, they subtract in the following manner. It is required, for instance, to take 14 from 23 (23—14) place the O mark of either scale to 23 on the other; find 14 on either scale, over it will be found 9, the result required. When a larger is taken from a smaller number, 100 is added to the latter. For instance, 14—23 is required, proceeding as before over 23 will be found 91. Should any subtraction be done mentally, as of course might be required, this addition of 100 to any smaller number must be remembered.

The C scale is that to which the results of the addition or subtraction of the base angles have to be referred, when reading ranges. At present all that is necessary is to show how they are read.

The scale, Fig. 7, begins at the large 0. Reading from this the tenth division is marked 1, the twentieth 2, and so on. These numbers, 1, 2, 3, &c., refer really to 10, 20, 30, &c.; on this part of the scale we can read up to 99, after which 0 recurs; as in the other scales 100 cannot be read. Reading on again, we find 10, 20, 30, &c., up to 79, this is the end of the scale. It will be seen then that any number up to 79 can be read in two parts of the scale; on the smaller divisions at the beginning, or the larger towards the end; and that any number between 80 and 99, on one part only, viz., on that towards the latter part of the smaller divisions.

Over this scale is D, Fig. 7. Starting from the division marked 2,000, it will be seen that the next is marked 21, and the tens continue up to 70, after which hundreds and thousands take their place.

It is on this scale that the tape mark of C $\left(\underset{\text{TAPE}}{\uparrow}\right)$ is set after the distance between the instruments has been measured with the tape; and on it also the range is read. Now the instruments

are not generally placed closer together than 20 yards, or further apart than 70 yards (the length of the tape); artillery ranges are seldom or ever so low as 800 yards; this is why we have the first part in tens, the latter in hundreds and thousands. Every number on the scale, however, may refer not only to the number marked on it, but to any multiple of such number and ten. For instance, 21 may refer to 21, 210, 2,100 and so on; the small mark between 21 and 22 may be 21·5 (21½), 215, 2,150, and so on. So that we are not confined to bases between 21 and 79. For 2,000 may be 20; 1,900, 19, and so on, or moving forwards 800 may be 80; 900, 90, &c. Nor are we confined to ranges of 800 yards and 2,000 yards, for 70 may be 700 yards, and 21, 2,100.

No uncertainty as to the correct reading can arise, for suppose the part of the C scale which points to the range to be opposite 21, the eye can easily detect, looking at the ground, whether it should be 210, 2,100, 21,000, or any other number which may be referred to by the 21 of the scale.

To the E scale (Fig. 10) has to be referred the difference of the angles read when taking the distance between the tripods by one instrument (Cases II. and IV.). Commencing at the unmarked division which, coming immediately before that marked 40, naturally refers to 30, the first small division is 31, the next 32, and so on, up to 40, then 41, 42—50, 60, 70, . . . 99. After this comes 0, as in all other cases, no 100 is marked; from this 0 we find 10, 20, 30, then 4, 5, 6, &c.; 4, 5, 6 here evidently point to 40, 50, 60, and this part of the scale goes on to 9 or 90, after which comes another 0, then 1, 2, 3, &c.; these refer to 10, 20, 30 as before. Up to the first 0 the intermediate units can be read on the scale, after it they have to be judged, with the exception of the 5's, which are marked. For instance, 37 can be read between the divisions 30 and 40 on the earlier portion of the scale; on the others it has to be judged; 35 can, however, be read on all three.

All numbers then, from 31 up to 99, can be read in three places in this scale, all below 31 on two only. No uncertainty, however, can arise as to which is the correct reading, as will be shown further on.

The tape is divided into yards, halves, and quarters; it is used for measuring the distance between the instruments.

The tape is liable to be broken by rough usage, or from becoming rotten from continual wetting. When this happens the two broken ends should be brought carefully together, not overlapping, and a small strip of leather or canvas sewn on so as not to shorten or lengthen it. If it is broken in the field tie the two ends together and subtract from the readings an amount equal to the length taken up in doing so.

A string is provided for use in Cases II. and IV., when the base has to be measured with an instrument instead of the tape. It is held by the No. in charge of either instrument as nearly at right angles to the base as possible, one end being fastened by a loop and toggle to the head of the tripod, a loop at the other

end being held by the hand, clear of the body, the palm towards the opposite instrument. The angles are taken from the head of the tripod to the forefinger. The E scale has a gun marked on it by which the distance between the instruments is read, using the length of the string as a base.

II.—METHODS OF USING THE INSTRUMENTS.

With these appliances four cases may arise, viz.:—

Case I.—Both instruments and the tape may be available.

Case II.—The tape may be broken, lost or unreliable. The two instruments only are then available.

Case III.—One instrument may be broken or lost. The other and the tape may be used.

Case IV.—One instrument and the tape are useless. One instrument alone is available.

The following is a description of the different methods used in each case:

CASE I.—TWO INSTRUMENTS AND THE TAPE. (FIG. 1.)

Suppose in Fig. 1 it is required to find the distance of C from A.

One instrument is placed on a tripod at A, it is first laid roughly by the sights fixed on the V's of the main telescope, as described at page 3. This first placed instrument is distinguished as the pivot instrument. As soon as the No. in charge of the other instrument, which is called the outer, sees that the pivot instrument has ceased shifting, he should place his, and lay on the object in the same manner. As soon as this is finished he should stand clear and commence measuring the base with the tape. The No. in charge of the pivot instrument, having laid its main telescope carefully by the cross wires, when he sees the other No. clear, lays his cross telescope on the opposite face, reads the angle, and registers it on the calculating disc, doubles over to the outer instrument, and sees that it is laid on the same spot of the same object. It is absolutely necessary, where the objects are confused, as they almost invariably are, that the same man should lay both telescopes so as to ensure this being the case.

When both cross telescopes have been laid on the opposite faces, the angles are read by the arc and vernier as described at page 4. They are then registered on the calculating disc and added together, as directed at page 5.

We will suppose a case; the base angle of the pivot instrument=23, the zero mark of A is placed to this number on B; the outer instrument gives 94, running the eye along A 94 is found on it, over this on B is 17, the sum of the angles.

Whilst this has been done, the distance between the instru-

ments has been measured by the tape, and is registered on the calculating disc by placing the tape mark of C $\left(\overset{\wedge}{\text{TAPE}}\right)$ to it on D. We will suppose this number to have been 65 yards.

Running the eye along the C scale, we find 17 on the larger divisions, over it on D is 1,800. The range may be and most likely is 1,800 yards. There is, however, another 17 on the scale, viz., on the smaller divisions, toward the commencement, over it is 815; 815 yards may therefore be the range. The eye, even if only slightly educated in estimating ranges, will settle at once which of these two is correct. In all the cases the larger is double or more than double the smaller.

If there should, however, be any doubt, shift the instruments to a different base, and the range which recurs is the true one. In this case, suppose we shift the instruments outwards till the base = 70 yards; and that on reading the angles the first is 24½, the second is 86; adding them, the result is 10½; over this number, on the larger divisions of D is 1,800 yards as before; over it, on the smaller, is 845; 1,800 yards is the correct range.

Even this uncertainty need never arise if the bases are kept within a certain proportion to the ranges. If the base is between $\frac{1}{115}$ and $\frac{1}{23}$ of the range, the reading will always fall on the larger part of the scale. If between $\frac{1}{23}$ and $\frac{1}{20}$, on the smaller divisions between 80 and 99, in which case no uncertainty can arise; for, as already shown, these numbers can be read on one part of the scale only. If between $\frac{1}{20}$ and $\frac{1}{12}$ of the range, on one of the smaller divisions. In the rules for practical working further on, bases are given for different ranges, which will always keep the readings on the larger numbers.

EXAMPLES.

Angles.		Sum by Scales A B	Base by Tape	Range. by D Scale.
A	B			
deg.	deg.	deg.	yards.	yards.
96	58	54	40	2000
63	36	99	53½	1214
80	51	31	69	2294
8	9	17	125	8450

CASE II.—TWO INSTRUMENTS AND NO TAPE. (Fig. 2.)

Case II. differs from Case I. in this particular, that the tape not being available, the distance between the instruments has to be measured by an instrument. It will be as well to describe this process separately.

The No. in charge of the outer instrument will, after they have been placed as in Case I., stand facing the other, and with the inner hand in the loop stretch the string as nearly as possible at right angles to the base, he will stand steady until he obtains a signal from the other instrument that he may *move. This will give* the base B M.

The cross telescope of the pivot instrument is now directed on the head of the tripod of the other, the angle is read and the 0 of F or G scale is set opposite to this number; then the vertical wire of the cross telescope is shifted till it just touches the forefinger of the No. at the outer instrument, and the angle is read. Run the eye along either F or G until this is found; opposite to it will be the difference between the two angles.

On the E scale find the difference just obtained, set the gun mark to it, clamp, and the tape mark will be set to the distance between the instruments. Here the difficulty alluded to at page 6 may arise. All numbers, from 31 to 99, can be found on three parts of this scale; all below this on two. Which, then, is the correct reading?

If A B (Fig. 1) is from 115 to 23 times B M, the readings will fall on the part of the scale between D and B (Fig. 2.) If from 23 to 12 times B M, between B and C (Fig. 2.) If the instruments are still closer, then between A and D. In fact, the closer the tripods are together, the further on the smaller numbers will the readings fall.

Even should these proportions not be remembered, no uncertainty should arise, for the eye will detect at once which is correct. For instance, the difference between the two angles is found to be 40. If the zero mark is set to the large 40, the distance read by the tape mark is 112 yards; if to the next 40, 32 yards; if to the smallest, 16¾ yards; and the eye cannot fail to see which is the correct distance.

We have, therefore, the tape set by this means, as in Case I. The instruments, too, have been placed in precisely the same manner, and the angle first read has been obtained precisely as the first angle in Case I.

All that remains, then, is to register the base angle thus obtained on B as in Case I., to lay the outer instrument, and take the angle, find it on A, over it on B will be their sum, find this number as before on E, over it on F is the range.

EXAMPLES.

Angles.		Difference by Scales F. G.	Base by Scales E. D.	Angles.		Sum by Scales A.B.	Range by D Scale.
B.	M.			A.	B.		
degrees.	degrees.	degrees.	yards.	degrees.	degrees.	degrees.	yards.
96	84	12	40	96	58	54	2000
5	72	33	33	5	15	20	946
47½	14	33½	130	46	31	15	2424

CASE III.—ONE INSTRUMENT AND THE TAPE. (FIG. I.)

With one instrument angles can be measured in one direction only. We cannot, therefore, proceed as in Case I. At present we will suppose the left instrument only to be available, and angles to the right therefore measured.

In Fig. 2, suppose the instrument placed at A and the main telescope laid carefully on C. Now place the cross telescope at right angles to the main telescope by making the 5 of the vernier correspond with the centre 0; look through it, and find some distinct object in, or nearly in, its field; such, for instance, as the tree at D. Lay its cross-wire carefully on this object, and by signal place the outer tripod in this line at a point B. As there are now two objects, we will call the first one the "far," the second the "square-object." This latter should always be as far away as convenient, 800 or 900 yards for example; such a distance is not necessary, but the greater it is the smaller are any errors. If no convenient object can be found, a man should be sent out dressed on to the point, and ordered to stick his sword in, or make some visible mark, and the observation is taken on this.

The instrument then being laid as described, viz., the main telescope on C, the cross on D, the angle is read, and as the two angles in this case have to be subtracted one from the other, the 0 of either the F or G scale is placed opposite it. The instrument is now shifted to the outer tripod at B, the main telescope laid on the far object C, the cross on the square object D, and the angle read; running the eye along F and G, find this angle; opposite it will be the difference between the two. Now find this difference on the C scale as before, over it on D will be the range. The base is measured and the tape mark set as in Case I.

All the remarks already made as to the proportion the bases ought to bear to the ranges, and the different places in which the numbers may have to be read on C, refer to this case equally with Case I.

It has one great advantage over Case I. If in the former the instruments read incorrectly, the range will be wrong. For instance, if that at A reads 4 too much, when we add $a + 4 + b$ the result will be larger than $a + b$, we shall find our range too long. But suppose the instrument reading 4 too much, to be used in this case, and call the two angles a and b; as both angles are read by the same instrument, each is 4 too much. Now $(a + 4) - (b + 4) = a - b$. It is the same thing, in fact, whether the instruments read right or wrong, the range is always correct.

EXAMPLES.

Angles.		Difference by Scales F. G.	Base by Tape.	Range by D Scale.
B	A			
degrees.	degrees.	degrees.	yards.	yards.
94	28	66	59½	1018
6	9	97	67	1492
36	36	100	91	2089

Case IV.—One Instrument only. (Fig. 2.)

Here, in addition to both angles having to be taken in one direction, as in Case III., the distance between the instruments has to be measured by the instrument. This part of the process is similar to the corresponding part of Case II., with this exception, the cross wire of the cross telescope on the tripod from which the distance is taken has to be laid on the head of the outer tripod, where the face would be if the instrument were in its place.

In this case, then, lay the pivot instrument as usual; choose the square object as in the last case, and place the outer tripod, taking care that the dressing is very exact; use the string with this tripod as usual. Now direct the cross telescope of the pivot instrument on the head of the outer tripod, where the face would be if the instrument were placed. Read this angle and set the 0 mark of F or G opposite it; shift the wire to the end of the string, read the angle, find it on the F or G scale, over it is the difference between the two. Place the gun mark to this number on E; the tape mark on D scale will then be set to the distance between the instruments.

Now shift the vertical wire back to the square object; read the angle and set the 0 mark of F or G to it (the angle just registered being no longer required, as the operation for which it was intended is finished). Then shift the instrument to the outer tripod, lay the main telescope on the far, the cross telescope on the square object, read the angle, find it on F or G; over it is the difference. Refer this difference to the C scale; over it on D is the range.

Examples.

Angles.		Difference by Scales F. G.	Base by Scales E. D.	Angles.		Difference by Scales F. G.	Range by D Scale.
B.	M.			A.	B.		
degrees.	degrees.	degrees.	yards.	degrees.	degrees.	degrees.	yards.
45½	72¼	72¼	59½	94	28	66	1018
7	42	65	67	6	9	97	1500

Taking the Range of Moving Objects.

It may at times be necessary to obtain the range of an object which is moving.

When this is the case the instruments are placed as in Case I. Both the Nos. in charge take the observations simultaneously, following the object up and calling out "on" when they are so. The officer conducting the operation places himself where he can hear and be heard by both; and, as soon as he hears two "on's" at the same moment, gives the word "halt," on which both Nos. quit the traversing screws. The two angles are then read, and the range is obtained as in Case I.

Case II. is also applicable to moving objects, the base being taken by either instrument before the range in the usual manner.

Of course the process is difficult, and liable to considerable error, from (1) the natural difficulty of following the same spot of the same object; (2) two observers being necessary; (3) their not calling "on" at the right time; (4) from the officer not "halting" when two "on's" exactly coincide; (5) from the numbers not halting at the precise moment ordered.

The liability to error varies with the amount of skill in the observers and the direction and pace at which the object travels. Under favourable circumstances fair accuracy is obtainable.

Of course Cases III. and IV. are wholly useless for these operations.

III.—RULES FOR PRACTICAL WORKING.

1. To keep the readings always on the larger numbers of the F and G scales, the following bases may be given:—

Under 1,100	yards range,	about 35	yards base.
From 1,100 to 1,500	„ „	40	„
„ 1,500 to 2,000	„ „	50	„
„ 2,000 to 2,500	„ „	60	„
„ 2,500 to 3,000 and upwards		70	„

And when taking the distance between the instruments, they should be from 40 yards to 110 yards apart.

2. In selecting a spot, remember that an instrument on a tripod is about 4′ from the ground.

3. Lay by the sights first, then with the telescope using the traversing screw, this latter should always be in the centre of the V when commencing.

4. Should the tape break, tie it together at two yard marks, and subtract a corresponding amount from the readings.

5. The main telescope is always laid on the right upper edge of objects to ensure similarity.

6. The same person should always, if possible, lay both instruments, especially when the objects or ground are confused.

7. In all additions, when doing them mentally, cast out hundreds; in all subtractions, when a larger is to be taken from a smaller, add 100 to the latter.

Case I.—Two Instruments and a Tape.

Place the pivot instrument, dress the outer on it, lay the main, then the cross telescopes, and read the angles. Set the tape mark of C to distance between the instruments on D. Set

zero mark of A to angle first read on B, find second angle on A, over it on B is their sum. Refer this to C, over it on D is the range.

CASE II.—TWO INSTRUMENTS, NO TAPE.

Instruments placed and laid as before, lay either cross telescope on opposite tripod head, place the 0 of F or G to this number, lay on end of string, find this angle on A or B, over it is the difference. Place gun mark to this on E and the tape mark is set; read the base angle of outer instrument, find it on A, over it on B is their sum. Refer it to C, over it on D is the range.

CASE III.—ONE INSTRUMENT AND THE TAPE.

Lay the pivot instrument, choose square object, place the outer tripod in line, take angle to square object, and place the 0 of F or G to it, read angle to square object at outer station, find this on F or G, over it is their difference. Measure the base and set the tape mark. Refer the difference to C, over it on D will be the range.

CASE IV.—ONE INSTRUMENT.

Lay pivot instrument, find square object, place outer tripod in line. Take angles, find their difference, place gun mark to this on E as in Case II. Then take angles to square object on both tripods, find their difference. Refer this to C, over it on D is the range.

IV.—METHODS OF TESTING AND ADJUSTING THE INSTRUMENTS.

The instruments when used with ordinary care are very unlikely to get out of order; they should, however, be tested from time to time.

There are two tests, the sun and the three-angle.

Theory of the sun test. The sun is at an infinite distance; consequently when the telescopes are laid upon the same portion of its disc, the two angles should be equal 180° or 100 on the range-finder.

Theory of the three-angle test. In Fig. 2, $a+b+c=100$

but $c=\text{C B D}-a$.

$\therefore a+b+(\text{C B D}-a)=100$.

Now, however much the instruments may be out of order, C B D$-a$ is always the truth. Any difference from 100 will be the error of $a+b$.

(1.) *The Sun Test.*

The two instruments very carefully dressed, and at any convenient distance apart, say 40 yards, are laid roughly by their

sights on the sun.* The object glasses of the main telescopes are covered with shutters, having a hole whose size must depend on the brightness of the sun; in the event of shutters not being at hand a piece of paper may be used. The object of this shutter is to protect the telescope from being injured by heat, for the same reason it is as well to cover the object glass with the hand, when not being actually looked through.

A colored glass shade is put over the eye-glass, not over the object glass for fear of unequal refraction.

Enough light should be left in the telescope to see the wires when off the sun.

The wires are laid on the sun so that the horizontal wire splits it and the vertical touches its right edge. The observers follow the sun with the screws, calling "on," they are halted by an officer as described for moving objects. The cross telescopes are then laid, and the readings taken; this should be done five times, then the observers should be shifted and five more observations taken, all doubtful ones being rejected. The whole when added together and divided by 10 should theoretically equal 100, or practically 99¾, the difference being caused by the cross telescopes being laid on the faces, not on each other.

The moon may also be used for this test, in which case no shutters are required.

(2.) *Three-Angle Test.*

The instruments should be placed as in Case III., the far object being at least 2,000 yards, the square 900 yards distant, great care being taken in dressing. The two base angles and the exterior angle have to be taken, and the equation at page 13, worked out.

Instruments having a minus error of 2 to 2½ may be said to be in good order, they should not be allowed to read too high.

There is no ready method of ascertaining which instrument is in fault, all we can know is that $a + b =$ more or less than $100 - c$ by a certain amount. It must, however, be a severe blow which will put an instrument out of order, and the one which shows signs of rough usage may be suspected.

When the amount of error has been ascertained, the following methods remedy it:—

1. Add or subtract the index error when reading the sum of the angles in Cases I. and II.; not, of course, in Cases III. and IV. where no amount of error can vitiate the result.
2. Make another zero mark on A, for instance, the error is + 4, place a fresh mark at 96.

DRILL.

For garrison artillery no special drill is required. The old drill for field service will, however, show the method of using the instruments. (See appendix.)

* For an hour and a half before sunset, or after sunrise, this can be done without digging holes for the trails. This does not apply when tripods are used.

APPENDIX.

Drill for Field Service.

Three mounted men are required, Nos. 1 and 2 to use the instruments, and No. 3 to act as horse-holder.

No. 1 on the left, 3 in the centre, and 2 on the right. No. 2 carries a tripod and tape. No. 3 carries the instruments and a tripod.

The tape is carried in a leather case slung over No. 2's shoulder by a strap.

The instruments are carried in wallets strapped to a leather numnah on No. 3's saddle. In each wallet there is a calculating roller and a magnifying glass.

The tripods are slung by a strap behind the right arm, the foot resting in a leather bucket fastened to the outside of the right stirrup-iron.

(1.) *Using the Tape.* (*Case I.*)

At the word "Halt, dismount," Nos. 1 and 2 ease off to the right and left to leave room to work and dismount, giving their bridoon reins to No. 3.

They unbuckle the wallets and take out the instruments, No. 3 giving a tripod to No. 1.

No. 1 tells No 2. the object of which the range is to be taken and the length of base; they then double out towards the flanks, No. 1 taking the end of the tape and No. 2 holding the case so as to allow it to run out.

As soon as No. 1 finds a convenient spot he fixes and lays his instrument roughly, sees that No. 2 is fairly at right angles, lays his instrument correctly, reads and registers the angle.

He then doubles over to the outer instrument, sees that it is correctly laid, and reads the angle.

He receives the length of base from No. 2, and at once reads off the range.

No. 2 places himself as nearly as possible at right angles to the range required, and at a distance from No. 1 about equal to the length of base named. As soon as he sees that No. 1 is satisfied with the position of his tripod, he lays his instrument roughly. He then reads the length of base accurately on the tape and communicates it to No. 1. If no more ranges are required from the same position, each takes the instrument at which he happens to be (generally No. 1 the right and No. 2 the left.) and replaces it.

(2.) *When the Tape is not used.* (*Case II.*)

The numbers proceed as before, except No. 2, who, as soon as he has placed his tripod, takes the string and holds it out to the front, as nearly at right angles to the base as possible, and stands steady until No. 1 has taken the angles necessary to calculate the length of base.

As soon as No. 1 comes to the outer (right), No. 2 goes to the pivot (left) tripod, and, when he sees No. 1 dismount the right instrument, he dismounts and doubles in with the left.

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(Wt. 22190. 375 | 4 | 82—H & S 3154.)

Fig. 1.

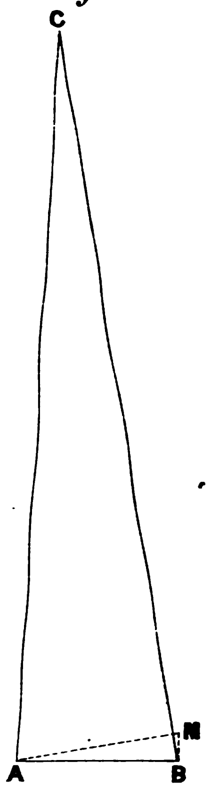


Fig. 2.

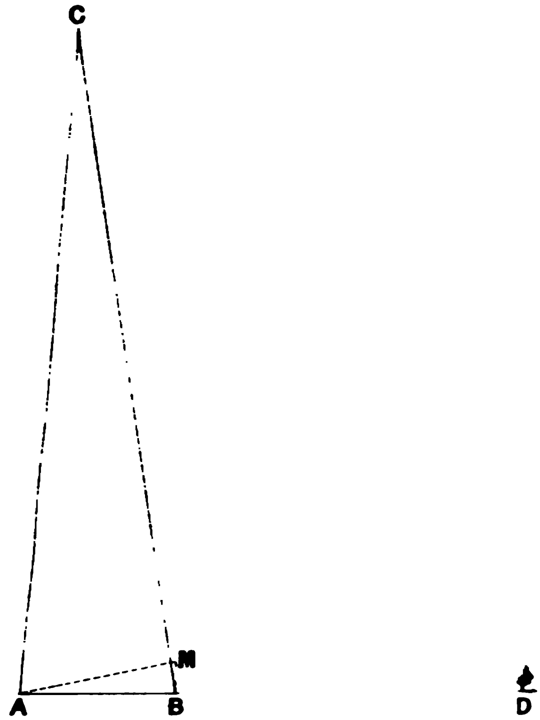
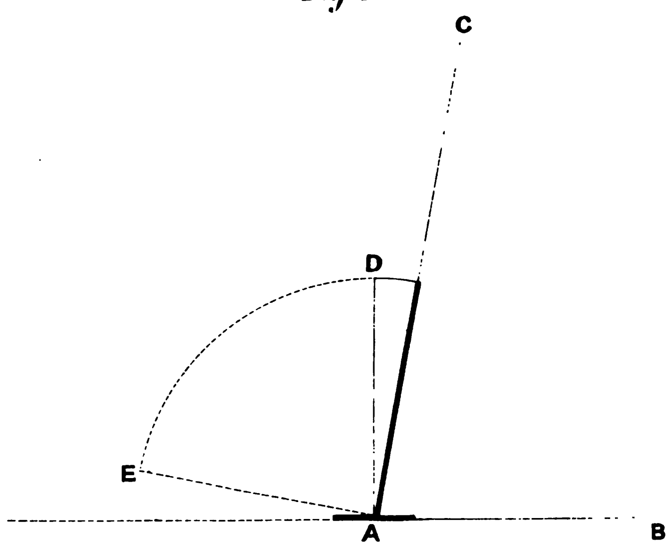


Fig. 3.



DANGERFIELD. LITH. 22. BEDFORD ST.

Fig. 4.

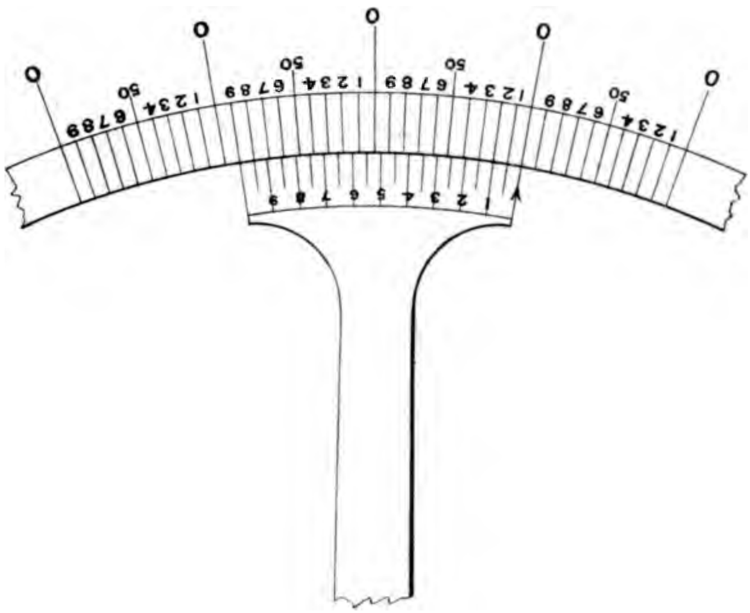
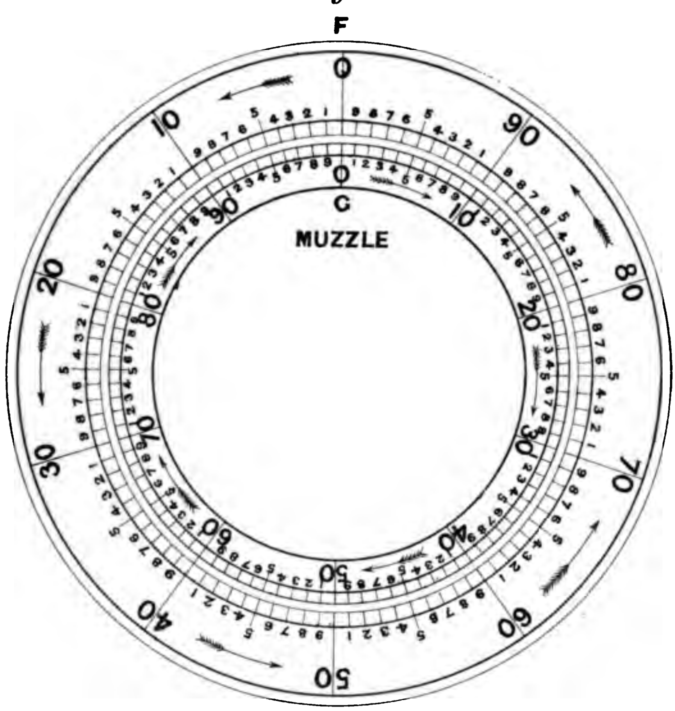


Fig. 5.



DANGERFIELD LITH. 22, BEDFORD ST. COVENT G

Plate III.

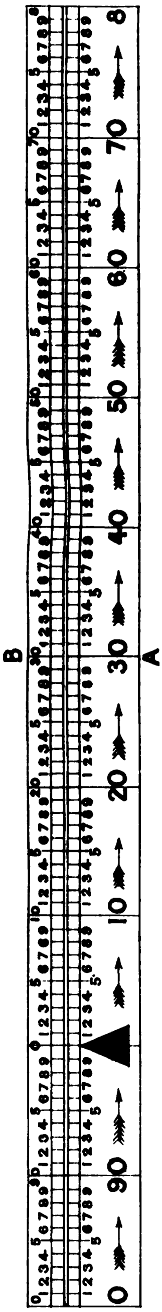


Fig. 6.

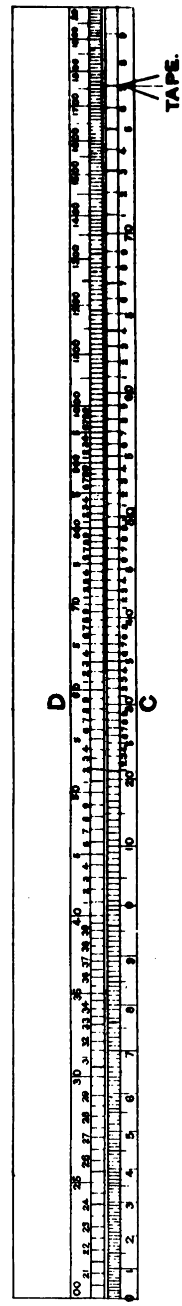


Fig. 7.

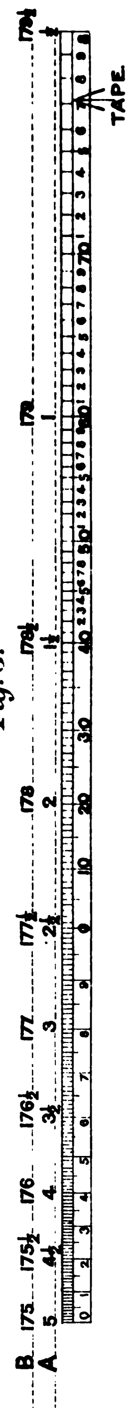
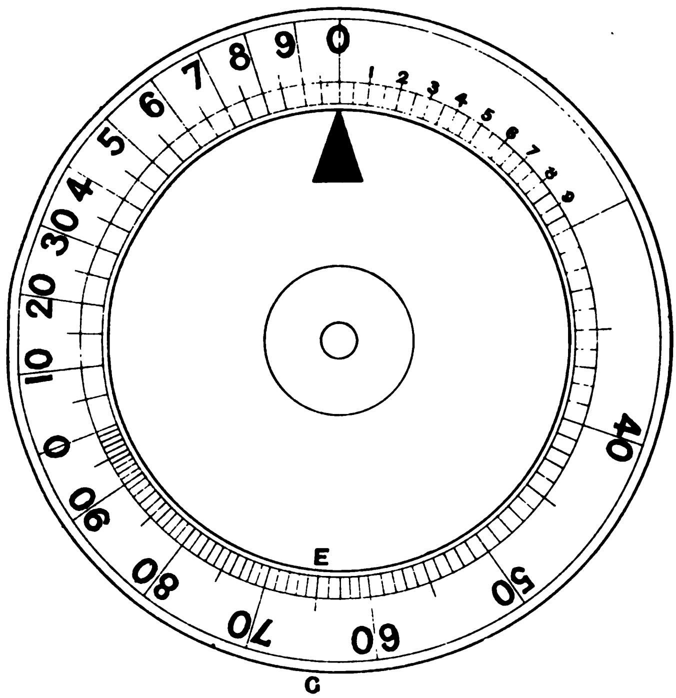


Fig. 8.

2976
Dangerfield Lith. 22. Bedford St. Covent Garden.

Fig. 9.



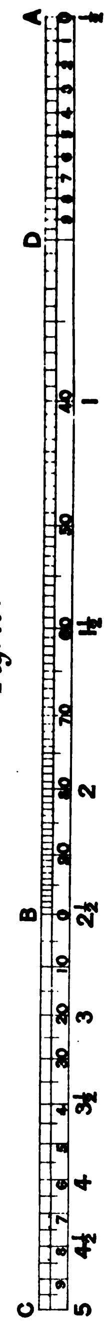


Fig. 10.

Dangerfield. Lith. 22. Bedford St. Covent Gard.